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December 14, 2021

VIA ELECTRONIC FILING

The Honorable Jocelyn G. Boyd
Chief Clerk and Executive Director
Public Service Commission of South Carolina
101 Executive Center Drive, Suite 100
Columbia SC 29210

**Re: Joint Petition of Duke Energy Carolinas, LLC and Duke Energy Progress, LLC
To Establish a Consolidated Informational Docket for Review and Consideration
of Grid Improvement Plans (NDI Opened Pursuant to Commission Order No.
2020-533)
Docket No. ND-2020-28-E**

Informational Update

Dear Ms. Boyd:

On August 12, 2020, by Order 2020-533 in Docket No. 2019-381-E, the Commission approved Duke Energy Carolinas, LLC's and Duke Energy Progress, LLC's (collectively, the "Companies") joint request to establish an informational docket for review and consideration of its Grid Improvement Plan. As a result of that order, on August 14, 2020, the Commission opened the above-referenced NDI docket. Since that time the Companies have provided the Commission periodic updates related to its Grid Improvement Plan.

The Grid Improvement Plan is a decade-long plan of near- and long-term actions and investments designed to transform the power grid, making strategic, data-driven improvements to power a smart-thinking grid that is more reliable, more resilient, and built to meet the energy needs of customers today and into the future. The Companies have held a number of stakeholder meetings during the execution of the Grid Improvement Plan and will continue to do so. Most recently, the Companies held virtual forums on October 26, 2021 and November 8, 2021. As a follow-up to requests for more information during these virtual forums, the stakeholders were provided with the attached document providing additional details on the Companies' 2022-2024 South Carolina Grid Improvement plans.

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The Companies will continue to inform stakeholders, the Office of Regulatory Staff, and the Commission on developments in the Companies' Grid Improvement Plans.

Kind regards,



Sam Wellborn

Attachment

cc: (via email w/ attachments)
Counsel for Office of Regulatory Staff
Counsel for Department of Consumer Affairs
Counsel for Sierra Club
Counsel for Walmart, Inc.
Counsel for SELC on behalf of SC NAACP, SCCCL & Upstate Forever
Counsel for Nucor Steel-South Carolina
Counsel for CCEBA and Cypress Creek Renewables
Counsel for SCEUC
Counsel for Vote Solar
Counsel for CMC Recycling
Hasala Dharmawardena

From: GIP-engagement
Sent: Monday, December 13, 2021 2:56 PM
Subject: South Carolina Grid Improvement Plan Informational Update
Attachments: SC GIP 2022-2024 Informational Packet.pdf



South Carolina Grid Improvement Plan Informational Update

Good afternoon,

As a follow-up to requests for more information during this Fall's virtual forums, please see the attached document for additional details on the Company's 2022-2024 SC GIP plans.

This document will also be filed in Docket No. ND-2020-28-E.

If you have any questions or feedback, please feel free to reach out to: GIP-Engagement@duke-energy.com.

Thank you for your continued interest in Duke Energy's Grid Improvement Plan.

Melissa Chandler Murphy

Director, Stakeholder Engagement

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South Carolina Grid Improvement Plan

As discussed in recent stakeholder engagement sessions, Duke Energy Carolinas, LLC's ("DEC") and Duke Energy Progress, LLC's ("DEP" and, together with DEC, the "Companies") Grid Improvement Plan ("GIP") focuses on better serving our customers, delivering reliable and resilient service to all communities we serve and preparing the grid for an energy future with diverse resource options. The Companies are improving the grid to reduce outage events impacting our customers and reduce the overall duration of outages when they occur. We're also strengthening the electric grid to make it more resistant to outages and making the grid more secure, to protect against the growing threat of cyber and physical attacks. And, we are transforming the grid to enable diverse energy resources, including cleaner energy options. Distributed energy resources ("DER") are important to our customers, and we believe growing these resources is an essential step towards building a cleaner energy future for South Carolina. Ultimately, these improvements will give customers more options and control to save energy and money.

As explained in past communications and most recently in the October 2021 webinar hosted by the Companies, the Grid Improvement Plan (e.g., GIP) was originally implemented to address seven macro "Megatrends" that were impacting the grid and shaping customer needs and expectations. Three years later, the Megatrends are continuing. As a result of the Megatrends and stakeholder feedback, the grid strategy must mature to balance outcomes across three objectives: resilience, DER enablement, and continued access to benefits for customers. While progress has been made in addressing these trends, continued improvement is needed.

Table 1 provides a list of the programs included in the GIP and the correlation to the megatrends being addressed by each program.

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Table 1: SC Grid Improvement Plan (“GIP”) programs – Megatrends addressed

GIP PROGRAMS	I - Phys & Cyber Threats	II - Adv Tech (Solar/Battery)	III - Environmental Policy	IV - Weather	V - Grid Improv Tech	VI - Concentrated Growth	VII - Cust Expectation
Physical & Cyber Security	x	x			x		x
Self-Optimizing Grid	x	x	x	x	x	x	x
Integrated Volt/VAR Control	x	x	x	x	x	x	x
Harden & Resiliency [T]		x	x	x			x
Targeted Underground				x			x
Energy Storage		x	x	x		x	x
Transformer Retrofit [D]				x			x
Long Duration Interruptions				x			x
Transformer Bank Repl [T]		x	x				x
Oil Breaker Rpl [T/D]			x		x		x
Enterprise Communications	x	x	x	x	x	x	x
Distribution Automation		x	x	x	x		x
System Intelligence [T]		x	x		x		x
Advanced Enterprise Systems		x	x		x		x
ISOP/ADP		x	x		x	x	x
DER Dispatch		x	x		x		x
Power Electronics		x	x		x		x

Key Accomplishments – Thru September 30, 2021

The grid programs began to address the Megatrends by identifying ways to modernize the current grid structure while increasing reliability and integrating evolving technologies. Since beginning this work, we have made significant progress, as outlined below from a sample of GIP programs:

The *Self-Optimizing (SOG)* program redesigns key portions of the distribution grid into a dynamic, smart-thinking, self-healing grid with the ability to automatically reroute power around trouble areas, to quickly restore power to the maximum number of customers and to enable better management of local distributed energy resources. This helps to reduce the number of outages,

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decrease the duration of outages up to 75% when they do occur, and help restore power in a matter of minutes. This system can detect issues before a customer reports a power outage.

Self-healing networks continue to prevent millions of customer minutes of interruption in SC, including 33.2 million minutes inception-to-date as of September 30, 2021.

- To date, we have installed self-healing technology to serve 8.7% of customers in DEC and 47.2% of customers in DEP in SC.
- The automated self-healing technologies have operated at a high success rate when called upon, at 100% and 97% for DEC and DEP YTD 2021, respectively.

Integrated Volt-Var Control (“IVVC”) program establishes control of distribution equipment in substations and on distribution lines to optimize delivery voltages to customers and power factors on the distribution line.

Optimizing delivery voltage means enabling grid operators to operate the distribution grid in a Conservation Voltage Reduction (“CVR”) mode that supports voltage reduction and energy conservation on a year-round basis, for approximately 90% of the hours in the year. Beginning in 2023, customers will see the benefits from avoided fuel and capacity costs from lower voltage on the distribution line. Customers are already benefiting from increased operational efficiency and improved VAR management using the controls that have been installed to date.

Through September 2021, the IVVC program has installed 13% of the capacitors, installed 55% of the regulator controls, completed 6% of the substations and completed 17% of circuits.

- The project is on track to begin testing completed substations in 2022 and automated control of distribution voltage starting in 2023 and ramping up to full implementation on all targeted substations by 2025.
- Although IVVC construction is not scheduled to be completed until 2023, the equipment is already providing increased operational awareness to distribution grid conditions.

The *Substation Flood Mitigation* subprogram, which builds in protection of substations most vulnerable to flood damage, was completed in South Carolina. An example of this work can be seen at the Nichols substation which experienced flooding during Hurricane Matthew. A flood mitigation wall and gate were constructed to a depth of approximately 18 feet below ground and reaching 8-9 feet above ground.

- There has been an increase in extreme flooding events across the Southeast in the last decade, and meteorologists expect this trend to continue.
- The Carolinas have experienced at least four 500-year flood events since 2015.

The *Transmission System Intelligence* program deploys transformational system monitoring and control equipment to enable faster response to outages and more intelligent analysis of issues on the grid. Installations of intelligent communication equipment have been completed at twenty-one South Carolina substations (88 Carolinas system-wide) as part of the Transmission System Intelligence program.

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The data collected from digital relays and condition-based monitors helps better assess and optimize transmission asset health.

- The installation of transformational grid monitoring and control equipment will allow for faster analysis and response to events.
- Increased automation enables a dynamic self-healing and remotely operated grid that improves flexibility and reduces duration of outages.

The *Long Duration Interruption/High Impact Sites (LDI/HIS)* program is designed to improve the reliability for parts of the grid with high potential for long duration outages as well as for high-impact customers like airports and hospitals. These prolonged outages may be caused by issues such as the company's inability to quickly access equipment during storm restoration or lack of alternate existing ties to the grid to provide power to some customers while outage causes are addressed.

Notable completed projects to date include:

- Cheraw - Pee Dee River Crossing
- Moore to Woodruff Tie
- Greenville Health System Critical Care
- Eddy Rd to Panaroma Tie

The *Enterprise Communication* program modernizes and secures the critical communications between intelligent grid management systems, data and controls systems, and sensing and control devices. With this technology we can:

- Route trucks more effectively during storms
- Perform our day to day work more efficiently
- Capture and utilize data for more efficient operations

Additionally, the Enterprise Communications program addresses technology obsolescence, secures vulnerabilities and provides new workforce-enabling capabilities. A few program highlights include:

- Vehicle Area Network (VAN) – Telematics portion of VAN project has been completed, benefitting customers by our improved ability to route repair crews for quicker power restoration.
- Mission Critical Transport – replacement and expansion of the fiber optic communications network to ensure there is sufficient and reliable bandwidth to transport information across the grid thus supporting all of our grid management devices, data and controls systems.
- Towers Shelters Power Supplies – replacement and expansion of communications towers as well as shelters and power supplies at tower locations allowing for more communication reliability and greater bandwidth to substations and intelligent grid devices.
- Next Generation Cellular – replacement of 2G/3G modems because of cellular provider phase out. These modems are being replaced with the newer 4G/5G modems in field locations to provide greater capacity, reliability, and security to the network.

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The *Cyber Security* program is focused on securing and improving risk mitigation on thousands of SCADA-controlled line devices (e.g. capacitors, regulators, recloser) through a combination of software and line device control upgrades.

- Through the completion of the Secure Access Device Management (SADM) project, the Companies are now able to better maintain passwords and retrieve fault files securely and remotely for thousands of SCADA controlled devices (i.e., regulators, capacitors, reclosers) in DEC and DEP.
- The Distribution Line Device Protection program completed the DEP Capacitor bank control upgrades in 2020 and the DEC recloser control changeouts in 2021. Future work will be required to continue upgrading line device controls.

The *Targeted Underground (TUG)* program strategically identifies the Companies most outage prone overhead power line sections and relocates them underground to reduce the number of outages experienced by customers.

The Targeted Underground program has converted more than 20 miles of outage prone parts of the system to underground. This maximizes outage elimination and allows for system restoration to occur more quickly and cost effectively to all customers in SC. Projects occurred in Chesterfield, Clarendon, Darlington, Dillon, Florence, Greenville, Lee, Marion, Spartanburg, Sumter, and Williamsburg counties.

The *ISOP* program integrates utility planning for generation, transmission, distribution and customer programs to improve the valuation and optimization of energy resources across the system.

The ADP Toolset (an ISOP tool) achieved full-scale deployment to distribution planners in the Carolinas in August 2021. Development of ADP tools and processes are transforming distribution planning by introducing automation to improve efficiency of complex analytical processes needed for DER deployment. The ADP Toolset will play a significant role in building a smarter, cleaner energy future as we strive to reduce CO₂ emissions.

Stakeholder Engagement Activities/Opportunities for Feedback

Following the initial filing of GIP information, we hosted four virtual forums for interested external GIP stakeholders, as detailed herein. On December 2, 2020, the Company reviewed its filed 2019 Annual Status Report with 13 external attendees who represented nine organizations. On May 12, 2021, the Company hosted another virtual forum to review the 2020 Annual Status Report with 13 external attendees who represented six organizations.

Two virtual forums were hosted on October 26 and November 8, 2021 to review preliminary plans for continuing the GIP work during the 2022-2024 timeframe and to request feedback from stakeholders. In the October 26 virtual forum, 14 external attendees representing ten organizations were present. In the November 8 virtual forum, 11 external attendees representing nine organizations were present. The Company appreciates the robust discussion and engagement that

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occurred during these Fall sessions. Participants proposed no changes to the 2022-2024 GIP plans put forth by the Company during these Fall sessions.

During all four virtual forums, stakeholders were given the opportunity to ask questions of and provide feedback to our program leaders. The Company plans to host an additional session to review the 2021 Annual Status Report in the second quarter of 2022.

Stakeholders requested more detail on continued plans for the 2022-2024 time frame, and we are providing this packet via email to all stakeholders and are happy to schedule a session to discuss this material upon additional request.

2022-2024 GIP Work

Preliminary capital spending expectations shared during the October and November virtual forums are shown below in Table 2. These estimated expenditures represent continued work within SC GIP programs for 2022-2024.

Table 2: Estimated Spend 2022 – 2024

Proposed Capital Expenditures by Program*	2022	2023-2024	Total 2022-2024
Self-Optimizing Grid	\$53.1M	\$85.0 – 103.9M	\$138.1 - 157.0M
Distribution H&R – Flood Hardening	\$2.7M	\$10.7 – 13.0M	\$13.3 - 15.7M
Distribution Transformer Retrofit	\$2.9M	-	\$2.9M
Integrated Volt/VAR Control	\$44.0M	\$27.2 – 33.2M	\$71.2 – 77.2M
Transmission H&R	\$25.0M	\$40.6 – 49.6M	\$65.6 – 74.6M
Transmission Transformer Bank Replacement	\$12.0M	\$15.8 – 19.3M	\$27.8 – 31.3M
Transmission System Intelligence	\$10.0M	\$8.6 – 10.5M	\$18.6 – 20.5M
Oil Breaker Replacement	\$24.1M	\$56.1 – 68.5M	\$80.2 – 92.6M
Targeted Undergrounding	\$14.0M	\$27.5 – 33.6M	\$41.5 – 47.6M
Energy Storage	\$0.1M	\$29.3 – 35.8M	\$29.4 – 35.9M
Long Duration Interruptions / High Impact Sites	\$0.8M	\$23.0 – 28.2M	\$23.8 – 28.9M
Enterprise Communications	\$22.3M	\$33.7 – 41.2M	\$56.0 – 63.5M
Distribution Automation	\$20.4M	\$37.6 – 45.9M	\$58.0 – 66.4M
Enterprise Applications	\$1.1M	\$1.3 – 1.6M	\$2.4 – 2.7M
ISOP	\$1.9M	\$2.9 – 3.5M	\$4.7 – 5.4M
DER Dispatch Tool	\$0.9M	\$1.4 – 1.7M	\$2.3 – 2.6M
Power Electronics for Volt/VAR	\$0.8M	\$3.7 – 4.6M	\$4.6 – 5.4M
Physical and Cyber Security	\$4.4M	\$4.9 – 6.0M	\$9.3 – 10.4M
Total	\$240.5M	\$409.1 – 500.1M	\$649.6 – 740.5M

Note: Dollars presented here and throughout the document are representative of current plans; however, estimates may be subject to change as they are progressively matured. Impacts from supply chain delays, resource availability or other unforeseen circumstances may significantly impact current estimates.

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Program Summaries

Program level details for each of the programs included in the 2022-2024 GIP are provided in this section.

Integrated Volt/Volt Var Control

The IVVC program establishes control of distribution equipment in substations and on distribution lines to optimize delivery voltages to customers and power factors on the distribution grid.

Description

IVVC allows the distribution system to optimize voltage and reactive power needs. The program employs remotely operated substation and distribution line devices such as voltage regulators and capacitors. The settings for thousands of these controllable field devices are optimized and dispatched via a distribution management system.

IVVC capabilities enable a grid operator to lower voltage as a way of reducing peak demand (peak shaving), thereby reducing the need to generate or purchase additional power at peak prices or protecting the system from exceeding its load limitations. The current DEP **Distribution System Demand Response (DSDR)** program uses the peak shaving mode of IVVC to support emergency load reduction.

Another operational mode enabled by IVVC capabilities on the distribution system is **Conservation Voltage Reduction (CVR)**. CVR uses IVVC during periods of more typical electricity demand to reduce overall energy consumption and system losses. IVVC leveraged in CVR mode allows grid operators to maintain voltage in the lower end of the acceptable voltage range, mitigating voltage increases from distributed load sources. By lowering voltage levels, CVR also conserves energy and can reduce peak load by approximately 1-2% on average.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Increase distributed intelligence
- Enable voltage control
- Accommodate two-way power flow
- Increase hosting and capacity
- Modernize grid operations and planning

Integrated Volt/Var Control	2022	2023 - 2024	Total 2022 - 2024
DEC	\$43.9M	\$27.2 - 33.2M	\$70.6 - 76.4M
DEP	\$0.1M	\$0.5 - 0.7M	\$0.6 - 0.8M
Total (range of expected spend)	\$44.0M	\$27.2 - 33.2M	\$71.2 - 77.2M

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Self-Optimizing Grid (SOG)

The Self-Optimizing Grid program, also known as the smart-thinking grid, redesigns key portions of the distribution system and transforms it into a dynamic self-healing network.

Description

The self-optimizing grid (SOG) uses self-healing technology to improve grid reliability. To detect potential faults in real time, the system uses sensors, switches, and controls. The self-healing system can recognize power outages and automatically adjust and minimize customer impact and restore power as quickly as possible. This helps to reduce the number of outages, decrease the duration of outages up to 75% when they do occur, and help restore power in a matter of minutes. This system can detect issues before a customer reports a power outage.

The SOG program reduces circuits to switchable segments to minimize the number of customers affected by sustained outages, expands the capacity to support the integrated grid network, and ensures the necessary connectivity to allow for rerouting options. SOG enables two-way power flows needed to support more rooftop solar, battery storage, electric vehicles, and microgrids – technologies that will increasingly power the lives of customers and move the state of South Carolina towards a cleaner energy future for all customers.

The current grid has limited ability to reroute or rapidly restore power and limited ability to optimize for the growing penetrations of distributed energy resources (DER). The SOG program is established to address both issues.

The SOG program consists of three (3) major components: grid capacity, grid connectivity, and automation and intelligence. The **SOG Capacity projects** focus on expanding substation and distribution line capacity to allow for two-way power flow. **SOG Connectivity projects** create tie points between circuits. **SOG Automation projects** provide intelligence and control for the Self Optimizing Grid. Automation projects enable the grid to dynamically reconfigure around trouble and better manage local DER.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Increase distributed intelligence
- Improve reliability
- Accommodate two-way power flow
- Increase hosting capacity

Self-Optimizing Grid	2022	2023 - 2024	Total 2022 - 2024
DEC	\$34.5M	\$56.0 - 68.4M	\$90.5 - 103.0M
DEP	\$18.6M	\$29.0 - 35.5M	\$47.6 - 54.1M
Total (range of expected spend)	\$53.1M	\$85.0 - 103.9M	\$138.1 - 157.0M

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Power Electronics Program

The Power Electronics program helps to reduce power quality issues associated with high DER penetration, and ultimately improves reliability to customers.

Description

As the adoption of distributed energy resources (DER) (e.g., customer-owned solar and energy storage) reaches critical levels and microgrid technology matures, power electronic technology must also advance to appropriately detect and respond to rapid voltage and power fluctuations that often accompany non-dispatchable resources such as solar.

As clouds move across the daytime sky and momentarily block sunlight from reaching solar panels, solar generation immediately ceases. As sunlight peaks through openings in the cloud cover, the solar panels begin generating, creating power spikes and voltage instability on the circuit. These intermittent power impacts occur and then change at rapid rates (in some cases sub-second) and frequently faster than the legacy electro-mechanical voltage management equipment like regulators and capacitors can handle.

Integrating advanced solid-state technologies like power electronics (i.e., static VAR compensators and other solid-state voltage support equipment), better equips the distribution system to manage power quality issues associated with increasing DER penetration.

The program is still in its early stages and current plans are small pre-scale deployments to validate capabilities and benefits.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Improve reliability
- Enable voltage control
- Accommodate two-way power flow
- Increase hosting capacity

Power Electronics for Volt/Var	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0.4M	\$1.2 - 1.5M	\$1.6 - 1.9M
DEP	\$0.4M	\$2.5 - 3.0M	\$2.9 - 3.5M
Total (range of expected spend)	\$0.8M	\$3.7 - 4.6M	\$4.6 - 5.4M

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Distribution Automation (DA)

The DA program improves how the distribution system protects the public and itself from unsafe voltage and current levels and, significantly reduces the impact experienced by customers due to grid issues.

Description

The capabilities offered through DA can transform what may have been an hour-long power outage for hundreds or even thousands of homes and businesses into a momentary outage – or potentially help avoid an outage altogether.

The DA consists of several complementary efforts that work in concert to support dynamic and growing distribution system loads in a more sustainable way while minimizing power quality issues that often accompany a large-scale transition to solar power. One of these projects, **Urban Underground System Automation**, modernizes the protection and control of underground power systems that serve critical high-density areas, such as urban business districts and airports. These improvements provide automatic power restoration capabilities during outages in most cases along with device communications for remote system monitoring.

The **Fuse Replacement** project focuses on replacing one-time use fuses with automatic operating devices capable of intelligently resetting themselves for reuse, thus eliminating unnecessary use of resources (inventory, time, gasoline, etc.). When a fault occurs beyond these new fuse replacement devices, the customer will only experience a momentary blink instead of a sustained outage the majority of the time.

The **Hydraulic to Electronic Recloser** program replaces obsolete oil-filled (hydraulic) devices with modern, remotely operated reclosing devices that support continuous system health monitoring. In some case, the addition of remote-control capabilities can help expedite power restoration efforts by allowing remote operations after manual fault isolation during outages.

Such digital device upgrades offer further value through efforts like the **System Intelligence and Monitoring** program. The deployment of advanced diagnostic tools helps engineers and technicians address electrical disturbances on the distribution system and improve customer experience. For example we are adding fault indicating sensors with remote communication capabilities to help pinpoint the location of faults to help reduce the outage duration.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Increase distributed intelligence
- Improve reliability
- Modernize grid operations and planning

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Distribution Automation	2022	2023 - 2024	Total 2022 - 2024
DEC	\$18.4M	\$25.4 - 31.0M	\$40.0 - 45.7M
DEP	\$2.0M	\$12.2 - 14.9M	\$18.0 - 20.7M
Total (range of expected spend)	\$20.4M	\$37.6 - 45.9M	\$58.0M - 66.4M

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Energy Storage

The Energy Storage program implements battery storage and other related non-traditional measures to defer, mitigate, or eliminate the need for traditional utility investments, such as line capacity upgrades.

Description

The program supports customer and utility initiatives through smart investments in storage for applications that deliver value to customers and the Company. These applications include microgrid projects for preventing planned and unplanned outages, as well as long-duration outage projects for providing redundant power sources for vulnerable (rural and remote) communities, and circuit and bank capacity projects using substation-tied energy storage.

Given the multiple applications energy storage technology supports, projects within the Energy Storage program are designed and assessed on a case-by-case basis for the specific challenge being addressed (e.g., long duration outage support, microgrid or emergency power support, auxiliary service needs, etc.).

The Energy Storage program also includes the development and deployment of an energy storage control system to manage the fleet of energy storage resources.

Grid Capabilities Enabled

- Improve reliability
- Increase distributed intelligence
- Enable voltage control
- Accommodate two-way power flow
- Increase hosting capacity (DER Enablement)
- Modernize grid operations and planning
- Expand customer options and control

Energy Storage	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0.05M	\$21.2 - 25.9M	\$21.2 - 25.9M
DEP	\$0.02M	\$8.1 - 9.9M	\$8.1 - 9.9M
Total (range of expected spend)	\$0.1M	\$29.3 - 35.8M	\$29.4 - 35.9M

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Integrated System Operations Planning (ISOP)

The ISOP program integrates utility planning for generation, transmission, distribution, and customer programs to improve the valuation and optimization of energy resources across the system.

Description

The energy resource mix is changing rapidly for electric utilities with the growth of renewable and distributed energy resources. Declining technology costs and policy support for renewable energy will likely make those resources increasingly competitive with traditional energy solutions. To properly compare these non-traditional solutions with traditional resources requires updates to utility planning processes. Integrated System Operations Planning (ISOP) process integrates utility planning for generation, transmission, distribution, and customer programs to improve the valuation and optimization of energy resources across all segments of the utility system to best serve electric customers.

The ISOP process addresses key operational and economic considerations across all segments of the system through integration and refinement of existing system planning tools and, in some cases, development of new analytical tools to assess characteristics that have not historically been captured or considered in long-term planning. Some examples include locational values for distributed resources, system ancillaries and reserves needed to support future operations, and energy resource flexibility to support new dynamic operational demands on the system.

ISOP is a multi-year development program to build the tools and processes needed to accommodate an increasingly integrated approach that will be required to optimize planning and operation of the electric utility system of the future.

Grid Capabilities Enabled

- Increase automation
- Increase distributed intelligence
- Improve reliability
- Enable voltage control
- Accommodate two-way power flows
- Increase hosting capacity

ISOP	2022	2023 - 2024	Total 2022 - 2024
DEC	\$1.4M	\$2.0 - 2.4M	\$3.3 - 3.7M
DEP	\$0.6M	\$0.9 - 1.1M	\$1.5 - 1.7M
Total (range of expected spend)	\$1.9M	\$2.9 - 3.5M	\$4.7 - 5.4M

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Long Duration Interruption/High Impact Sites (LDI/HIS)

The LDI/HIS program is designed to improve the reliability for parts of the grid with a high potential for long duration outages as well as for high-impact customers like airports and hospitals.

Description

The LDI/HIS program is designed to improve the reliability in parts of the grid where the duration of potential outages is expected to be much higher than average. Focus areas for this program are radial feeds to entire communities or large groups of customers as well as inaccessible line segments (i.e. off road, swamps, mountain gorges, extreme terrain, etc.).

Many of the areas served by these long, rural, single-sourced feeders can experience significant impacts to the local economy and to quality of life when the entire town loses power. Further, operational and repair costs are generally higher than average in these areas due to the special equipment required.

While some sites may include extreme hardening, circuit relocations, new circuit ties and undergrounding, energy storage solutions may offer more cost-effective solutions for improving reliability and managing costs.

The LDI/HIS program is also designed to improve the reliability of high- impact customers like airports and hospitals, and high-density areas that could require a variety of infrastructure solutions to improve power quality and reliability. Typical projects include substation upgrades, circuit ties, voltage conversions, and reconductoring.

Grid Capabilities Enabled

- Improve reliability
- Harden for resiliency

LDI/HIS	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0.8M	\$0M	\$0.8M
DEP	\$0M	\$23.0 - \$28.2M	\$23.0 - \$28.2M
Total (range of expected spend)	\$0.8M	\$23.0 - \$28.2M	\$23.8 - \$28.9M

**Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's
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Targeted Undergrounding (TUG)

The TUG program strategically identifies the Company's most outage prone overhead power line sections and relocates them underground to reduce the number of outages experienced by customers.

Description

Overhead power line segments with a history of unusually high numbers of outages drive a disproportionate amount of momentary interruptions and outages that affect our customers. When these segments of lines fail, they cause problems for customers directly served by them as well as customers upstream. Lines targeted to be moved underground are typically the most resource-intensive parts of the grid to repair after a major storm. Equipment on these line segments can experience shortened equipment life and additional equipment-related service interruptions.

The goal of the TUG program is to maximize the number of outage events eliminated. Converting outage prone parts of the system enables us to restore service more quickly and cost effectively for all customers. Addressing areas with outlier outage performance improves service while lowering maintenance and restoration costs for all customers.

Criteria for consideration in the selection of targeted communities include:

- Performance of overhead lines
- Age of assets
- Service location (e.g., lines located in backyard where accessibility is limited)
- Vegetation impacts (e.g., heavily vegetated and often costly and difficult to trim)

Grid Capabilities Enabled

- Improve reliability
- Harden for resiliency
- Modernize grid operations and planning

Targeted Undergrounding	2022	2023 - 2024	Total 2022 - 2024
DEC	\$10.0M	\$18.0 - 22.0M	\$28.0 - 32.0M
DEP	\$4.0M	\$9.5 - 11.6M	\$13.5 - 15.6M
Total (range of expected spend)	\$14.0M	\$27.5 - 33.6M	\$41.5 - 47.6M

**Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's
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Distribution Transformer Retrofit

The Distribution Transformer Retrofit program converts existing overhead distribution transformers to deliver the same reliability benefits as a modern transformer installed today.

Description

Like the Self-Optimizing Grid program, the new sectionalization capability of a retrofitted transformer works to minimize the number of customers impacted by fault or failure on the power line. In addition, like the Targeted Undergrounding program, the new protective features that mitigate equipment vulnerabilities work to significantly lower the risk of an outage occurring at the transformer all together.

The core activities of the transformer retrofit program include the installation of a fuse disconnect device on the high-voltage side of every overhead transformer to protect upstream customers from a fault at or downstream of the transformer. In addition, through protective device coordination, the local fused disconnect can be set to prevent any upstream operations of reclosing devices (the source of momentary outages for customers not served by the retrofitted transformer.)

Consistent with modern transformer standards, the program also retrofits transformers with additional protective elements to reduce the risk of external factors such as lightning strikes and animal interference. Lightning strikes cause outages by raising voltage levels of equipment past operating levels while animals cause outages by either chewing equipment or creating a connection between equipment thus causing faults.

Grid Capabilities Enabled

- Improve reliability
- Modernize grid operations and planning

Distribution Transformer Retrofit	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0M	\$0M	\$0M
DEP	\$2.9M	\$0M	\$2.9M
Total (range of expected spend)	\$2.9M	\$0M	\$2.9M

**Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's
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Distribution Hardening & Resiliency – Flood Hardening

The Distribution H&R – Flood Hardening targets areas where an overlay of actual outage events from Hurricanes Matthew and Florence intersect with the 100-year flood plain.

Description

In hurricane events like Hurricane Floyd and more recently Hurricanes Matthew and Florence, significant flooding was a major factor impacting restoration. Smart, targeted investments can mitigate the scale of impacts on communities and customers adjacent to these areas prone to extreme flooding. Hardening lines and structures is a balanced approach that can keep power and critical services available to some portion of a community and prevent a widespread outage in an area until flooding recedes.

This program includes the following:

- Alternate power feeds for substations in flood-prone areas, and for radial power lines that cross into and through flood-prone areas
- Hardened river crossings where power lines are vulnerable to elevated water levels and where access issues may occur during extreme flooding
- Additional guying for at-risk structures within flood zones to prevent poles and equipment from being displaced and remain upright

Grid Capabilities Enabled

- Improve reliability
- Harden for resiliency
- Improve physical security

Distribution H&R – Flood Hardening	2022	2023 - 2024	Total 2022 - 2024
DEC	\$2.5M	\$1.7 - 2.1M	\$4.2 - 4.6M
DEP	\$0.1M	\$9.0 - 11.0M	\$9.1 - 11.1M
Total (range of expected spend)	\$2.7M	\$10.7 - 13.0M	\$13.3 - 15.7M

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Transmission System Intelligence

The Transmission System Intelligence program deploys transformational system monitoring and control equipment to enable faster response to outages and more intelligent analysis of issues on the grid.

Description

Transmission grid automation improvements will reduce the duration and impacts associated with transmission system issues.

Improvements in transmission system device communication capabilities enable better protection and monitoring of system equipment. The data collected from intelligent communication equipment helps better assess and optimize transmission asset health.

The Transmission System Intelligence program includes:

- The replacement of electromechanical relays with remotely operated digital relays,
- The implementation of intelligence and monitoring technology capable of providing asset health data and driving predictive maintenance programs, and
- The deployment of remote monitoring and control functionality for line and substation devices for rapid service restoration.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Improve reliability
- Accommodate two-way power flow
- Modernize grid operations

Transmission System Intelligence	2022	2023 - 2024	Total 2022 - 2024
DEC	\$8.9M	\$7.4 - 9.0M	\$16.3 - 17.9M
DEP	\$1.1M	\$1.2 - 1.5M	\$2.3 - 2.6M
Total (range of expected spend)	\$10.0M	\$8.6 - 10.5M	\$18.6 - 20.5M

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Transmission Hardening & Resiliency

The Transmission (H&R) program works to create a stronger and more resilient transmission grid capable of withstanding or quickly recovering from extreme external events, natural or man-made.

Description

Each Transmission H&R sub-program works to address unique challenges in ways that harden the system, and not only minimize impacts to customers, but enhance their electric service experience. The **44-kV System Upgrade** subprogram both protects the 44-kV system from extreme weather, but also paves the way for more DER interconnections by creating additional capacity on the system to transport generation from large scale solar sites. Similarly, the **Targeted Line Rebuild for Extreme Weather** subprogram protects some of the higher voltage transmission lines from extreme weather by addressing vulnerable wooden structures.

The **Substation Flood Mitigation** subprogram builds in protection for substations most vulnerable to flood damage; and the **Animal Mitigation** subprogram installs equipment specifically designed to prevent animal induced events from impacting customers directly through an outage or indirectly through a system perturbation such as a voltage depression. Altogether,

these H&R efforts not only enhance the functionality of individual assets, but substantially improve the overall functionality of the system, particularly under extreme weather conditions.

The long-term plan for hardening and resiliency is to relocate or strengthen at-risk assets or other solutions such as flexible mitigation at that site.

Grid Capabilities Enabled

- Improve reliability
- Harden for resiliency
- Improve physical security
- Accommodate two-way power flow
- Optimize hosting capacity for DER

Transmission H&R	2022	2023 - 2024	Total 2022 - 2024
DEC	\$21.4M	\$39.7 - 48.5M	\$61.1 - 69.9M
DEP	\$3.6M	\$0.8 - 1.0M	\$4.5 - 4.6M
Total (range of expected spend)	\$25.0M	\$40.6 - 49.6M	\$65.6 - 74.6M

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Transformer Bank Replacement

The Transformer Bank Replacement program leverages new system intelligence capabilities to target transformers before they fail and optimizes hosting capacity for DER penetration.

Description

Predictive and proactive replacement programs like Transformer Bank Replacement significantly reduce the impacts and costs of replacement when compared to performing the same work following a catastrophic failure. In addition, the transformers are evaluated for hosting capacity to support future adoption of distributed energy resources (DER). As part of the transformer replacement, advanced protection and control devices will enable two-way power flow from future DER connections.

The objective of this program is to anticipate future transformer failures and replace those transformers in an orderly fashion, avoiding the cost and customer outage minutes associated with these failures. Catastrophic failures often result in significant oil spills, requiring expensive cleanup and other mitigation.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Improve reliability
- Modernize grid operations & planning
- Optimize hosting capacity of DER

Transformer Bank Replacement	2022	2023 - 2024	Total 2022 - 2024
DEC	\$9.0M	\$7.0 - 8.6M	\$16.1 - 17.6M
DEP	\$3.0M	\$8.8 - 10.7M	\$11.8 - 13.7M
Total (range of expected spend)	\$12.0M	\$15.8 - 19.3M	\$27.8 - 31.3M

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Breaker Replacement

The Breaker Replacement program identifies and replaces oil-filled circuit breakers on the transmission and distribution systems with modern technology.

Description

The purpose of this program is to replace these legacy assets with breaker technology capable of two-way communications and remote operations. Looking forward, these fast-response gas and vacuum breakers are better suited for protecting circuits with higher solar and other variable energy resource penetration.

Transmission level oil breakers will be replaced with modern sulfur hexafluoride gas (SF6) circuit breaker technology. The medium voltage distribution level oil-filled breakers will be replaced with modern vacuum circuit breaker technology.

The new communication and control capabilities of this modern technology better positions the transmission and distribution systems to work with grid automation systems to better respond to electric grid events.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Improve reliability
- Modernize grid operations and planning

Oil Breaker Replacement	2022	2023 - 2024	Total 2022 - 2024
DEC	\$20.0M	\$40.5 - 49.5M	\$60.5 - 69.5M
DEP	\$4.1M	\$15.6 - 19.0M	\$19.6 - 23.1M
Total (range of expected spend)	\$24.1M	\$56.1 - 68.5M	\$80.2 - 92.6M

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Physical & Cyber Security

The Physical and Cyber Security program protects against potential risks and reduces impacts of attacks on the electric grid.

Description

This portfolio focuses on hardening the physical and cyber security of the substations above the standard regulatory compliance requirements. Transmission elements of the program include:

- Enhancements to physical security measures and increased monitoring capabilities at substations that are critical to the reliability of the grid.
- Replacement of Windows-based relays to address cyber security standards.
- Enhancement to cyber security at non-bulk electric system (BES) substations
- Increase protection against Electromagnetic Pulse and Intentional Electromagnetic Interference (EMP/IEMI).

At the distribution system level, much of the focus involves securing and improving risk mitigation of remotely controlled field equipment. An example is enabling door alarms and entry notifications. Another example is enabling password maintenance and retrieval of fault files securely and remotely for the thousands of line devices in DEC and DEP.

Programs include:

- Distribution Line Device Cyber Protection
- Secure Access Device Management (SADM) - a single tool to remotely and securely perform device management activities and event record retrieval on the entire transmission and distribution device inventory.

Grid Capabilities Enabled

- Harden for resiliency
- Improve cyber security
- Improve physical security
- Increase monitoring and visibility
- Increase automation
- Improve reliability

Physical & Cyber Security	2022	2023 - 2024	Total 2022 - 2024
DEC	\$3.0M	\$0.2 - 0.3M	\$3.2 - 3.3M
DEP	\$1.5M	\$4.6 - 5.6M	\$6.0 - 7.0M
Total (range of expected spend)	\$4.4M	\$4.9 - 6.0M	\$9.3 - 10.4M

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Enterprise Communications Advanced Systems

The Enterprise Communications program modernizes and secures the critical communications between intelligent grid management systems, data and controls systems, and sensing and control devices.

Description

The program addresses technology obsolescence, secures vulnerabilities, and provides new workforce-enabling capabilities. This program includes improvement and expansion of the entire communications network from the high-speed, high-capacity backbone fiber optic and microwave networks to the wireless connections at the edge of the grid. These upgrades help build the secure communications required for the increasing number of smart components, sensors, and remotely activated devices on the transmission and distribution systems.

Key communication efforts are: (1) *Mission Critical Transport* which strategically upgrades the infrastructure required for high-speed, reliable, sustainable, interoperable communications for grid devices and personnel; (2) *Grid Wide Area Network* (Grid WAN) which improves network reliability, performance and security for current grid management/control applications; (3) *Mission Critical Voice* which replaces current Land Mobile Radio systems with enhanced, reliable, sustainable, interoperable communications across all service territories; and (4) *Next Generation Cellular* which replaces obsolete 2G/3G cellular technology with the more reliable and secure 4G/5G technology required for modern grid devices in the field.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Improve reliability
- Enable voltage control
- Accommodate two-way power flow
- Improve cyber security

Enterprise Communications Advanced Systems	2022	2023 - 2024	Total 2022 - 2024
DEC	\$14.4M	\$23.7 - 29.0M	\$37.8 - 43.1M
DEP	\$8.3M	\$10.0 - 12.3M	\$18.2 - 20.4M
Total (range of expected spend)	\$22.3M	\$33.7 - 41.2M	\$56.0 - 63.5M

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Enterprise Applications

The Enterprise Applications program deploys the systems and upgrades needed to monitor the health and security of the grid and analyze data to enable grid automation and optimization technologies.

Description

Upgrades to existing enterprise applications enable system optimization and overall better system performance. Within the program, there are two main components responsible for the delivery of enterprise technology solutions that support transmission, distribution, and other critical lines of business: (1) *Enterprise Systems* and (2) *Grid Analytics*.

This effort focuses on delivering transformative, cross-functional technical solutions to the enterprise in non-disruptive ways. The *Outage Timestamp Accuracy* project integrates outage data from Advanced Metering Instructure (AMI) to improve the accuracy of historical outage data.

Grid Analytics optimizes the electric system health and performance through the deployment of the *Health Risk Management* (HRM) tool and *Enterprise Distribution System Health* (EDSH) tool. These tools help to prevent equipment failures and improve asset performance on the transmission and distribution systems, respectively.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase automation
- Increase distributed intelligence
- Improve reliability
- Enable voltage control
- Accommodate two-way power flow
- Improve physical security

Enterprise Applications	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0.8M	\$1.1 - 1.3M	\$1.9 - 2.1M
DEP	\$0.3M	\$0.2 - 0.3M	\$0.5 - 0.6M
Total (range of expected spend)	\$1.1M	\$1.3 - 1.6M	\$2.4 - 2.7M

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DER Dispatch Enterprise Project

The DER Dispatch Enterprise Project is a software-based solution that provides operators with the ability to monitor and manage both transmission and distribution connected DERs.

Description

This tool project will coordinate with the Distribution Management System (DMS) and Energy Management System (EMS) to improve the way DERs are integrated in the energy supply mix, both at the Distribution and the bulk power level.

By providing system-wide visualization and control of large-scale DERs, the DER Dispatch Tool Project will enable system operators to model, forecast, and dispatch a portfolio of distributed energy resources, like solar generation, and energy storage, based on system conditions and real-time customer demand. This tool project will help meet the need to match energy demand with supply, especially in emergency conditions.

Current processes and tools provide system operators with a rudimentary ability to quickly shed large blocks of solar generation in emergency conditions to meet standards for real power control. The proposed solution will provide operators with a more automated and refined toolset to optimize management of both utility and customer owned DERs to meet system stability requirements.

DER Dispatch increases grid capabilities resulting in more DER interconnections. Absent this tool, the grid will reach a threshold where DER interconnections will no longer be accepted due to safety and reliability risks. Hence, DER Dispatch is an operational tool that permits real time control. For example, a DER Dispatch operation could mitigate an emergency condition such as an over-generation event by dispatching utility and third-party owned DERs (i.e. solar farms/energy storage sites/etc.). Since DER Dispatch enables precise grid control, then more DERs can interconnect with the grid. Future phases for DER Dispatch include economic dispatch which will influence our participation in SEEM through the aggregation of utility and third-party owned DERs. Economic dispatch furthers the expansion of DERs thus increasing the overall economic development in a geographic region.

This system will replace an existing tool in DEP that is used to dispatch distribution connected solar in 50 MW increments.

Grid Capabilities Enabled

- Increase monitoring and visibility
- Increase distributed intelligence
- Enable voltage control
- Accommodate two-way power flow
- Expand customer options and control

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DER Dispatch Enterprise Project	2022	2023 - 2024	Total 2022 - 2024
DEC	\$0.7M	\$1.1 - 1.3M	\$1.8 - 2.0M
DEP	\$0.2M	\$0.3 - 0.4M	\$0.5 - 0.6M
Total (range of expected spend)	\$0.9M	\$1.4 - 1.7M	\$2.3 - 2.6M